The Functional Value of Cortical Cerebral Motor Centres in Different Animals.

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THE FUNCTIONAL VALUE OF CORTICAL CEREBRAL MOTOR CENTRES IN DIFFERENT ANIMALS.*

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It is impossible to excite in the pigeon any of the ordinary movements of the limbs or trunk by electrical stimulation. This I have established by a long series of experiments. The same applies to the domestic fowl, and probably to all or nearly all birds, though it would be interesting to know whether it holds for the parrot with its remarkable handlike motor power. On removal of the entire cerebral cortex in the pigeon, nearly all the movements of which the intact bird is at any time capable can still be called forth, though none of them are now voluntary. This seems to indicate that the mechanism necessary for executing such movements exists somewhere else than in the cerebral cortex, presumably

* This paper, accompanied by demonstrations, was read before the Canada Medical Association in Montreal, August 27, 1896. Dr. J. W. Scane, demonstrator of physiology in McGill University, assisted in the required operative procedure, etc.

chiefly in the subcortical centres of the cerebrum, or, at all events, in the encephalon somewhere.

We have found that cats from which we had removed at one operation both the areas around the crucial sulcus (which corresponds fairly well functionally with the fissure of Rolando), and in which the centres for the head and limbs lie, can walk in some fashion as soon as they recover from the anæsthetic, and they gradually move better and better, so that even within the few days that they survive this operation they have to a considerable degree recovered their ordinary gait. Our cats thus operated on refused food entirely, and notwithstanding some forced feeding, which was not very satisfactory, died in a few days.

But cats from which the same areas were removed within a few days by successive operations did well, and, to ordinary observation, walked within even three or four days afterward as though their brains were intact.

The kitten I show you to-day could also "wash its face" with both paws as well as any cat on the fourth day after the removal of the second motor region referred to above.

In dogs the recovery is slower, in my experience, but nevertheless occurs to a large extent.

The rabbit can walk after removal of the greater part of the entire cerebral cortex, and the hind legs seem almost unaffected at any time.

After operations of a similar though less grave character on the monkey there is decided paralysis from which there may be slow recovery. The same seems to be the course of events following surgical removal of parts of the motor area in man; but in his case, and sometimes in the monkey, the paralysis is very lasting.

I could demonstrate to you, did time permit, that in the rabbit, cat, and dog the different areas (centres) of the cerebral cortex are not on the same functional plane. It is evident, from contrasting these animals—especially if we include the bird—with the monkey and with man that the expression "motor centres" should convey a very different meaning according as we speak of one or the other.

Had this been realized earlier, the controversies that have raged over cortical localization would have at least been of a less heated character. It is to my own mind clear, after considerable investigation of this subject on a variety of animals, that we must recognize that localization exists in varying degrees in different animals, and also that cortical centres are very differently organized. In the bird there are none of the ordinary cortical motor centres at all, if one can settle such a question by electrical excitation.

In all the other animals referred to in this paper the writer has found that:

1. Certain areas of the cerebral cortex respond to electrical excitation by movements.

2. Certain areas have a different though analogous distribution in different animals.

3. These movements are more readily excited, are more elaborate, and their centres are less readily exhausted in some animals than in others.

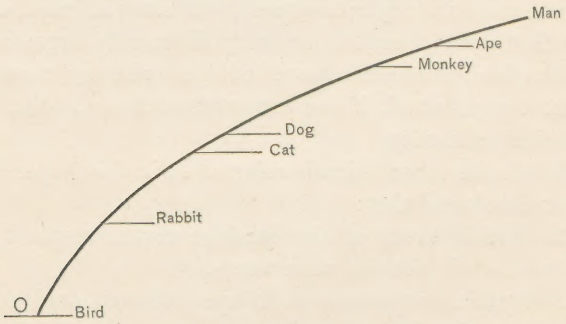
4. The exact location of the motor centres is better defined the higher we ascend in the animal scale.

In all the foregoing there are variations for individuals.

To put the whole matter briefly, we must recognize in different animals (and to some extent in different in-

dividuals) all degrees of functional cortical development; and it is further capable of demonstration that all centres in the same animal are not equally well organized, or, in other words, are not on the same physiological plane. In the rabbit, for example, the centres for the facial movements and those of the fore limb are better developed than others, and in the dog and the cat the centres for the fore limbs are better organized than those for the ears or tail; and the same applies throughout.

We may draw a curve to express these facts and place the different groups of animals in their physiological order thus:



This is further evident, as I have elsewhere shown, by tracing the functional development of the cerebral cortex in the young of the rabbit, guinea-pig, rat, mouse, cat, and dog.

There is a time when no reasonable strength of current will, when applied to the cortex, give rise to movements in those animals which are born blind, but later, and in a regular order, the centres are developed.

Such a conception of motor centres is in harmony

with the facts of clinical medicine. It is well known that all movements in man are not equally readily abolished by cerebral disease or equally readily restored.

Do not such facts as these demonstrations impress on us make the relative part played by higher and lower centres plainer in man as well as in the lower animals? Evidently, cortical centres are relatively more important in man; but the view that even in man they can not be replaced by others to some extent seems to me to lack foundation either in physiological experiment or in clinical medicine.

The case resolves itself into a difference in degree as concerns man and the lower animals, and to make in some measure this great truth evident has been the main purpose of these demonstrations.

Demonstrations.—The principles stated above were illustrated by demonstrations on the pigeon, the rabbit, the cat, and the dog.

A pigeon from which the entire cerebrum had been removed an hour before was shown to be capable of flight when thrown into the air.

A rabbit, with ablation of the motor centres for the limbs and the neck on both sides, on the day previous, by a single operation, was able to jump vigorously, only the merest tendency to slipping of the fore paws on a smooth surface being noticeable.

A mature cat that had been the subject of operation about the middle of June—the area around the right crucial sulcus having been excised—appeared to move and act in all respects like a normal cat. More remarkable still was the case of a kitten a few months old. About five weeks ago the cortical centres for the limbs and neck on one side were excised, and two weeks

since the same operation was done on the opposite side. It was difficult to distinguish in the movements of this kitten any difference from those of a normal cat. Its intelligence seemed to be little if at all altered. It walked, ran, washed its face, etc., to all intents and purposes like any other cat under ordinary circumstances.

A puppy three months old had the circumcrucial motor area (for neck, arm, and leg) removed about a week before. It could walk, run, scratch with its hind legs, etc., though there was a tendency to slip, and at times a bending under of the paw on the side opposite to the lesion. This is somewhat analogous to wrist-drop in the human subject.

The puppy was rapidly recovering, though at present he illustrated a condition that, in a somewhat more marked degree, immediately follows operation in the cat also, and to a lesser extent in the rabbit. It should not be termed paralysis.

The two areas that had been removed from the kitten, and the single one from the puppy, were exhibited. It was perfectly plain from these demonstrations that cortical " motor centres " had not the same signification, relations, etc., in these animals as in the monkey and in man.

All the operations were performed under an anæsthetic, and the wounds healed rapidly.

It should also be pointed out that in each instance the motor areas were determined by electrical stimulation of the cortex with the rapidly interrupted current of a Du Bois inductorium.

These demonstrations in themselves warrant the cautions expressed in regard to theories of localiza-

tion in my *Text-book of Physiology* * at the date of its publication, and I am as firmly convinced as ever that it is only by the comparative method that broad, sound, and enduring laws can be established in this or any other department of physiology, on which human and comparative medicine must each alike rest.

* *A Text-book of Animal Physiology.* D. Appleton & Co., New York, 1889.